What is claimed is:

1. A design data generating apparatus for generating new design data of an article by performing a shape transformation process with respect to design data of the article which has been already generated, the apparatus comprising:

an input device for receiving transformation instructions from an operator; and

an operation device for performing an operation of the design data in accordance with the transformation instructions which are input,

wherein

the input device receives input of allocation of a shape attribute of the article between an attribute of a transformation region for which the shape transformation process is to be performed and an attribute of a maintaining region which maintains its shape, and input of a transformation instruction vector which is defined by a direction and an amount of transformation with respect to the article, and

the operation device fixes a node located at a boundary between the transformation region and the maintaining region, and displaces a node not located at a boundary between the transformation region and the maintaining region in accordance with the input transformation instruction vector.

2. An apparatus according to claim 1, wherein

the shape of the article is composed of a base shape and an auxiliary shape, and

the operation device performs a transformation process only with respect to the base shape, and adds the auxiliary shape to the design data after the shape transformation process.

3. An apparatus according to claim 1, wherein the input received by the input device from the operator includes instructions for an operative node of the transformation instruction vector.

4. An apparatus according to claim 3, wherein the instructions for an operative node of the transformation instruction vector include point designation concerning a single node, line designation concerning a line connecting nodes, and plane designation concerning a plane enclosed by nodes.

5. A design data generating method for generating new design data of an article by performing a shape transformation process with respect to design data of the article which has been already generated, the method comprising:

a region attribute input step of receiving, from an operator, allocation of a shape attribute of the article between an attribute of a transformation region for which the shape transformation process is to be performed and an attribute of a maintaining region which maintains its shape;

a transformation instruction input step of receiving, from the operator, a transformation instruction vector which is

defined by a direction and an amount of transformation with respect to the article, and

a shape transformation processing step of performing a displacement process with respect to a node of a shape element in accordance with the transformation instruction vector which is input, a node located at a boundary between the transformation region and the maintaining region being fixed and a node not located at the boundary between the transformation region and the maintaining region being displaced.

6. A method according to claim 5, wherein

the shape of the article is composed of a base shape and an auxiliary shape, and

a transformation process is performed only with respect to the base shape, and the auxiliary shape is added to the design data after the shape transformation process.

7. A method according to claim 5, wherein

in the shape transformation processing step,

(1) the transformation region is subdivided into a plurality of shape elements; and

(2) displacement of a node which defines the shape of the shape elements is performed, wherein

when a node is located on a single bending line of an article, the node is displaced in the extending direction of the bending line and by an amount corresponding to a component

of the input transformation vector in the extending direction of the bending line,

when a node is located on the intersection of a plurality of bending lines of an article, the node is displaced in the extending direction of the bending line which forms the smallest angle with respect to the transformation vector and by an amount corresponding to a component of the input transformation vector in the extending direction of the bending line, and

when a node is not located on the bending line of a article, the node is displaced in accordance with a vector obtained by projecting the transformation instruction vector onto an extension plane of an article shape plane at that node.

8. A method according to claim 5, wherein

in the transformation instruction input step, the input received by the input device from the operator includes instructions for an operative node of the transformation instruction vector.

9. A method according to claim 8, wherein

the instructions for the operative node of the transformation instruction vector include point designation concerning a single node, line designation concerning a line connecting nodes, and plane designation concerning a plane enclosed by nodes.

10. A method according to claim 5, wherein

in the shape transformation processing step, when an edge line connecting nodes of the transformation region is to extend beyond a node belonging to the boundary between the maintaining region and the transformation region as a result of node displacement in accordance with the transformation instruction vector input by the operator,

(1) the transformation instruction vector input by the operator is divided into a first transformation instruction vector which terminates where the edge line connecting nodes in the transformation region reaches a node in the maintaining region and a second transformation instruction vector which starts where the edge line connecting the nodes in the transformation region reaches the node in the maintaining region;

(2) a shape transformation process in accordance with the first transformation instruction vector is performed only with respect to the transformation region which is designated by the operator;

(3) the attribute of the maintaining region including the node which contacts the edge line of the transformation region is reallocated as the attribute of the transformation region; and

(4) a shape transformation process in accordance with the second transformation instruction vector is performed with respect to the transformation region, including the reallocated transformation region, of the article shape which has been subjected to the transformation process in accordance with the first transformation instruction vector.

11. A method according to claim 10, wherein

in the transformation instruction input step, the input includes an allowable angle between the transformation instruction vector and the article bending line,

wherein in the shape transformation processing step, a node for which the angle formed by the transformation instruction vector and the bending line is less than the allowable angle is displaced in the extending direction of the bending line, and

a node for which the angle formed by the transformation instruction vector and the bending line is equal to or greater than the allowable angle is displaced in accordance with the transformation vector.

12. A design data generating apparatus for generating new design data of the article by performing a shape transformation process with respect to design data of the article which has been already generated, the apparatus comprising:

an input device for receiving transformation instructions from an operator; and an input device for receiving transformation instructions from an operator; and

an operation device for performing an operation of the design data in accordance with the transformation instructions which are input,

wherein

the input device receives input for defining one of the edge lines of the existing article shape as a moving original

line, input for designating a moving destination line which is a destination of the moving original line, and input for designating a fixed edge line, and

the operation device provides nodes to the existing article shape at predetermined intervals, generates a cross sectional shape of the existing article formed by a normal plane at each node on the moving original line, rearranges a normal plane cross sectional shape which crosses the fixed edge line by performing similarity-like transformation for moving a node belonging to the moving original line to a corresponding point on the moving destination line, and rearranges a normal plane cross sectional shape which does not cross the fixed edge line to a corresponding point on the moving destination line,

whereby a new article shape defined by a series of the similarity-like transformation cross sectional shapes and the normal plane cross sectional shapes which have been rearranged is generated.

13. An apparatus according to claim 12, wherein

the operation device provides shape nodes at predetermined intervals on the normal shape cross sectional shape, and moves a shape node in accordance with a shape node moving vector which is obtained by multiplying a moving vector from a node belonging to the moving original line to the corresponding point on the moving destination line by a ratio of a distance from the fixed edge line to the shape node divided by a distance from the node belonging to the moving original line to a corresponding point on the fixed edge line, thereby

performing similarity-like transformation of the normal plane cross sectional shape.

14. An apparatus according to claim 12, wherein

the input device receives input for designating a non-transformation region from the existing article shape, and

the operation device does not transform a shape which belongs to the non-transformation region of the normal plane cross sectional shape.

15. An apparatus according to claims 12, wherein

the input device receives input for designating a fixed shape from the existing article shape, and

the operation device fixes the fixed shape.

16. An apparatus according to claim 12, wherein

the input device receives input for designating a ratio of movement of a node and a normal plane cross sectional shape from the node on the moving original line to a corresponding point on the moving destination line and input for designating whether or not the destination is limited to the corresponding point on the moving destination line, and

the operation device moves the node and the normal plane cross sectional shape to a point on a line segment connecting the node on the moving original line and the corresponding point on the moving destination line in accordance with the designated movement ratio when the destination is limited, and moves the node and the normal plane cross sectional shape to a

point on the extending line of a line segment connecting the node on the moving original line and the corresponding point on the moving destination line in accordance with the designated movement ratio when the destination is not limited.

17. An apparatus according to claim 12, wherein

the input device receives input of a lower limit value of radius of curvature of the moving original line, and

the operation device provides a new additional node at a position, between nodes on the moving original line where the radius of curvature is smaller than the lower limit radius of curvature, by which the moving original line between these nodes is divided by n (n is an integer equal to or greater than 1), generates an additional normal plane cross sectional shape of the existing article at the additional node, and similarly performs the similarity-like transformation cross sectional shape generation and rearrangement with respect to the additional normal plane cross sectional shape.

18. An apparatus according to claim 12, wherein

the input device receives moving original line dividing instructions for dividing the moving original line into two or more sections, and

the operation device performs a first similarity-like transformation process by performing similarity-like transformation only for a normal plane cross sectional shape belonging to a first divided moving original line which has been divided and moving a node so as to maintain continuity of

an article shape while fixing a control point which defines a shape plane defining a normal plane cross section belonging to a second divided moving original line continuous to the first divided moving original line,

subsequently performs a second similarity-like transformation process by performing similarity-like transformation only for a normal plane cross sectional shape belonging to a second divided moving original line which has been divided and moving a node so as to maintain continuity of an article shape while fixing a control point which defines a shape plane defining a normal plane cross section belonging to a third divided moving original line continuous to the second divided moving original line, and

thereafter sequentially performs the similar transformation process for the entire moving original line, so that boundaries at the divided lines of a new article shape are smooth.

19. An apparatus according to claim 12, wherein

the input device receives input for defining one of the edge lines of the existing article shape as a first moving original line and defining another one of the edge lines, other than the first moving original line, as a second moving original line, and input for designating a first moving destination line which is a destination of the first moving original line and designating a second moving destination line which is a destination of the second moving original line, and

the operation device provides nodes to the existing article shape at predetermined intervals, generates a cross sectional shape of the existing article formed by a normal plane at each node on the first moving original line, rearranges a normal plane cross sectional shape which crosses the second moving original line by performing similarity-like transformation for moving a node belonging to the first moving original line to a corresponding point on the first moving destination line and moving a node belonging to the second moving original line to a corresponding point on the second moving destination line, and rearranges a normal plane cross sectional shape which does not cross the second moving original line to a corresponding point on the first moving destination line,

whereby a new article shape defined by a series of the similarity-like transformation cross sectional shapes and the normal plane cross sectional shapes which have been rearranged is generated.

20. An apparatus according to claim 19, wherein

the operation device provides shape nodes at predetermined intervals on the normal shape cross sectional shape, and moves a shape node in accordance with a first shape node moving vector which is obtained by multiplying a first moving vector from a node belonging to the first moving original line to the corresponding point on the first moving destination line by a ratio of the distance from the second moving original line to the shape node of interest divided by a distance from the node

on the first moving original line to a corresponding point on the second moving original line, and further moves a shape node in accordance with a second shape node moving vector which is obtained by multiplying a second moving vector from a node belonging to the second moving original line to the corresponding point on the second moving destination line by a ratio of a distance from the first moving original line to the shape node divided by a distance from the node on the second moving original line to a corresponding point on the first moving original line, thereby performing similarity-like transformation of the normal plane cross sectional shape.

21. An apparatus according to claim 12, wherein

the input device receives input for designating a plane on which a cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process is to be arranged at a point on the moving destination line, and

the operation device arranges the cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process on the plane which is designated,

whereby a new article shape defined by a series of cross sectional shapes which are arranged is generated.

22. An apparatus according to claim 21, wherein

the input device receives input of moving destination line normal plane arrangement designation which designates a normal plane of the moving destination line, and

the operation device arranges the cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process on the normal plane at a point on the moving destination line.

23. An apparatus according to claim 21, wherein

the input device receives input of moving original line normal plane designation which designates a plane parallel to a normal plane of the moving original line which is the origin of movement, and

the operation device arranges the cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process on a plane parallel to a normal plane of the moving original line which is the origin of movement.

24. An apparatus according to claim 12, wherein

the input device receives input for designating a type of correspondence between a node on the moving original line and a point on the moving destination line, and

the operation device moves the node and the normal plane cross sectional shape of the node to a point in accordance with the designated type of correspondence.

25. An apparatus according to claim 24, wherein

the input device receives input for designating equal internal division ratio correspondence for causing a node on the moving original line to correspond to a point on the moving destination line at which a line segment of the moving

destination line is internally divided with an internal division ratio which is equal to the internal division ratio by which the node internally divides a line segment of the moving original line, and

the operation device, when the equal internal division ratio correspondence is designated, moves the node at which the internal division ratio on the moving original line is A and the normal plane cross sectional shape at the node to a point on the moving destination line at which the internal division ratio is A, in the similarity-like transformation process and the rearrangement process.

26. An apparatus according to claim 24, wherein

the input device receives input for designating moving destination line perpendicular line correspondence for causing a node on the moving original line to correspond to a point on the moving destination line such that a perpendicular line expending from the point on the moving destination line crosses the node on the moving original line, and

the operation device, when the moving destination line perpendicular line correspondence is designated, moves the node on the moving original line and the normal plane cross sectional shape at the node to a point on the moving destination line from which a perpendicular line extends and crosses the node on the moving original line, in the similarity-like transformation process and the rearrangement process.

27. An apparatus according to claim 24, wherein

the input device receives input for selecting moving original line perpendicular line correspondence for causing a node on the moving original line to correspond to a crossing point between a normal plane at the node and the moving destination line, and

the operation device, when the moving original line perpendicular line correspondence is designated, moves the node and the normal plane cross sectional shape at the node to a crossing point between a normal plane at the node and the moving destination line, in the similarity-like transformation process and the rearrangement process.

28. An apparatus according to claim 24, wherein

the input device receives input for selecting designated plane correspondence for causing a node on the moving original line to correspond to a crossing point between a plane which is parallel to one designated plane and which contains the node and the moving destination line and input for designating the one plane, and

the operation device, when the designated plane correspondence is designated, moves the node on the moving original line and the normal plane cross sectional shape at the node to a crossing point between a plane which is parallel to one designated plane and which contains the node and the moving destination line.

29. An apparatus according to claim 24, wherein

the input device receives input of additional correspondence designation for further designating a correspondence destination of the node and the normal plane cross sectional shape at the node for which no corresponding point exists on the moving destination line, and

the operation device moves the node and the normal plane cross sectional shape at the node for which no corresponding point exists on the moving destination line based on the correspondence designated by a correspondence designation device to a point in accordance with the additional correspondence designation.

30. An apparatus according to claim 29, wherein

the input device receives input for designating moving destination line extension additional correspondence for causing the node on the moving original line to correspond to a point on the extending line of the moving destination line from which a perpendicular line extends and crosses the node on the moving original line, and

the operation device moves the node and the normal plane cross sectional shape at the node for which no corresponding point exists on the moving destination line based on the correspondence designated by the correspondence designation device to a point on the extending line of the moving destination line from which a perpendicular line extends and crosses the node on the moving original line.

31. An apparatus according to claim 29, wherein

the input device receives input for designating nearest point additional correspondence for causing the node on the moving original line to correspond to the nearest point on the moving destination line, and

the operation device moves the node and the normal plane cross sectional shape at the node for which no corresponding point exists on the moving destination line based on the correspondence designated by the correspondence designation device to the nearest point on the moving destination line.

32. A design data generating method for generating new design data of an article by performing a shape transformation process with respect to an existing article shape, the method comprising:

a node providing step of providing a node to the existing article shape at predetermined intervals;

a moving original line defining step of defining one of the edge lines of the existing article shape as a moving original line;

a normal plane cross sectional shape generating step of generating a cross sectional shape of the existing article formed by a normal plane at each node on the moving original line;

a moving destination line designating step of designating a moving destination line which is a destination of the moving original line;

a fixed edge line designating step of designating a fixed edge line from the existing article shape;

a similarity-like transformation cross sectional shape generating and rearranging step of rearranging a normal plane cross sectional shape which crosses the fixed edge line by performing similarity-like transformation for moving a node belonging to the moving original line to a corresponding point on the moving destination line; and

a cross sectional shape rearranging step of rearranging a normal plane cross sectional shape which does not cross the fixed edge line to a corresponding point on the moving destination line,

wherein a new article shape defined by a series of the similarity-like transformation cross sectional shapes and the normal plane cross sectional shapes which have been rearranged is generated.

33. A method according to claim 32, comprising:

a shape node providing step of providing shape nodes at predetermined intervals on the normal shape cross sectional shape,

wherein in the similarity-like transformation process, the shape node moves in accordance with a shape node moving vector which is obtained by multiplying a moving vector from a node belonging to the moving original line to the corresponding point on the moving destination line by a ratio of a distance from the fixed edge line to the shape node divided by a distance from the node belonging to the moving original line to a corresponding point on the fixed edge line, thereby

performing similarity-like transformation of the normal plane cross sectional shape.

34. A method according to claim 32, comprising:

a non-transformation region designating step of designating a non-transformation region from the existing article shape,

wherein in the similarity-like transformation process, a shape which belongs to the non-transformation region of the normal plane cross sectional shape is not transformed.

35. A method according to claim 32, comprising:

a fixed shape designating step of designating a fixed shape from the existing article shape,

wherein in the similarity-like transformation process, the fixed shape is fixed.

36. A method according to claim 32, comprising:

a movement ratio designating step of designating a ratio of movement of a node and a normal plane cross sectional shape from the node on the moving original line to a corresponding point on the moving destination line; and

a movement extension permission designating step of designating whether or not the destination is limited to the corresponding point on the moving destination line, wherein

in the similarity-like transformation process and the rearrangement process,

when the destination is limited, the node and the normal plane cross sectional shape is moved to a point on a line segment connecting from the node on the moving original line and the corresponding point on the moving destination line in accordance with the designated movement ratio, and

when the destination is not limited, the node and the normal plane cross sectional shape is moved to a point on the extending line of a line segment connecting the node on the moving original line and the corresponding point on the moving destination line in accordance with the designated movement ratio.

37. An apparatus according to claim 32, comprising:

a lower limit radius of curvature defining step of defining a lower limit value of radius of curvature of the moving original line; and

an additional node providing step of providing a new additional node at a position, between nodes on the moving original line where the radius of curvature is smaller than the lower limit radius of curvature, thus dividing the moving original line between these nodes by n (n is an integer equal to or greater than 1), wherein,

in the normal plane cross sectional shape generating step, an additional normal plane cross sectional shape of the existing article at the additional node is generated, and the similarity-like transformation cross sectional shape generation and rearrangement are similarly performed with respect to the additional normal plane cross sectional shape.

38. A method according to claim 32, comprising:

a moving original line dividing instructing step of receiving moving original line dividing instructions for dividing the moving original line into two or more sections, wherein

in the similarity-like transformation cross sectional shape generating and rearranging step, a first similarity-like transformation process is performed by performing similarity-like transformation only for a normal plane cross sectional shape belonging to a first divided moving original line which has been divided and moving a node so as to maintain continuity of an article shape while fixing a control point which defines a shape plane defining a normal plane cross section belonging to a second divided moving original line continuous to the first divided moving original line,

subsequently a second similarity-like transformation process is performed by performing similarity-like transformation only for a normal plane cross sectional shape belonging to a second divided moving original line which has been divided and moving a node so as to maintain continuity of an article shape while fixing a control point which defines a shape plane defining a normal plane cross section belonging to a third divided moving original line continuous to the second divided moving original line,

thereafter a similar transformation process is sequentially performed for the entire moving original line, so

that boundaries at the divided lines of a new article shape are smooth.

39. A method according to claim 32, comprising:

an arrangement plane designating step of designating a plane on which a cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process is to be arranged at a point on the moving destination line,

wherein the cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process is arranged on the plane which is designated, and

a new article shape defined by a series of cross sectional shapes which are arranged is generated.

40. A method according to claim 39, wherein

the arrangement plane designation includes moving destination line normal plane arrangement destination which designates a normal plane of the moving destination line, and

the cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process is arranged on the normal plane at a point on the moving destination line.

41. A method according to claim 39, wherein

the arrangement plane designation includes moving original line normal plane destination which designates a plane parallel to a normal plane of the moving original line which is the origin of movement, and

the cross sectional shape which has been subjected to the similarity-like transformation and rearrangement process is arranged on a plane parallel to a normal plane of the moving original line which is the origin of movement.

42. A method according to claim 32, comprising a correspondence designation step of designating a type of correspondence between a node on the moving original line and a point on the moving destination line,

wherein in the similarity-like transformation process and the rearrangement process, the node and the normal plane cross sectional shape of the node is moved to a point in accordance with the designated type of correspondence.

43. A method according to claim 42, wherein

the correspondence type includes equal internal division ratio correspondence for causing a node on the moving original line to correspond to a point on the moving destination line at which a line segment of the moving destination line is internally divided with an internal division ratio which is equal to the internal division ratio by which the node internally divides a line segment of the moving original line, and

when the equal internal division ratio correspondence is designated, the node at which the internal division ratio on the moving original line is A and the normal plane cross sectional shape at the node moves to a point on the moving destination line at which the internal division ratio is A, in

the similarity-like transformation process and the rearrangement process.

44. A method according to claim 42, wherein

the correspondence type includes moving destination line perpendicular line correspondence for causing a node on the moving original line to correspond to a point on the moving destination line such that a perpendicular line extending from the point on the moving destination line crosses the node on the moving original line, and

when the moving destination line perpendicular line correspondence is designated, the node on the moving original line and the normal plane cross sectional shape at the node moves to a point on the moving destination line from which a perpendicular line extends and crosses the node on the moving original line, in the similarity-like transformation process and the rearrangement process.

45. A method according to claim 42, wherein

the correspondence type includes moving original line perpendicular line correspondence for causing a node on the moving original line to correspond to a crossing point between a normal plane at the node and the moving destination line, and

when the moving original line perpendicular line correspondence is designated, the node and the normal plane cross sectional shape at the node moves to a crossing point between a normal plane at the node and the moving destination

line, in the similarity-like transformation process and the rearrangement process.

46. An apparatus according to claim 42, wherein

the correspondence type includes designated plane correspondence for causing a node on the moving original line to correspond to a crossing point between a plane which is parallel to one designated plane and which contains the node and the moving destination line,

a plane designating step of designating the one plane is provided, and

when the designated plane correspondence is designated, in the similarity-like transformation process and the rearrangement process, the node on the moving original line and the normal plane cross sectional shape at the node moves to a crossing point between a plane which is parallel to one designated plane and which contains the node and the moving destination line.

47. A method according to claim 42, wherein

the correspondence designated in the correspondence designating step includes additional correspondence designation for further designating a correspondence destination of the node and the normal plane cross sectional shape at the node for which no corresponding point exists on the moving destination line, and

in the similarity-like transformation process and the rearrangement process, the node and the normal plane cross

sectional shape at the node for which no corresponding point exists on the moving destination line based on the correspondence designated by the correspondence designating step are moved to a point in accordance with the additional correspondence designation.

48. A method according to claim 47, wherein

the additional correspondence includes moving destination line extension additional correspondence for causing the node to correspond to a point on the extending line of the moving destination line from which a perpendicular line extends and crosses the node on the moving original line, and

when the moving destination line extension additional correspondence is designated,

in the similarity-like transformation process and the rearrangement process, for the correspondence designated in the correspondence designating step, the node and the normal plane cross sectional shape at the node for which no corresponding point exists on the moving destination line based on the correspondence designated by the correspondence designating step are moved to a point on the extending line of the moving destination line from which a perpendicular line extends and crosses the node on the moving original line.

49. A method according to claim 47, wherein

the additional correspondence includes nearest point additional correspondence for causing the node on the moving

original line to correspond to the nearest point on the moving destination line, and

when the nearest point additional correspondence is designated,

in the similarity-like transformation process and the rearrangement process, for the correspondence designated in the correspondence designating step, the node and the normal plane cross sectional shape at the node for which no corresponding point exists on the moving destination line based on the correspondence designated by the correspondence designating step are moved to the nearest point on the moving destination line.

50. A design data generating method for generating new design data of an article by performing a shape transformation process with respect to an existing article shape, the method comprising:

a node providing step of providing a node to the existing article shape at predetermined intervals;

a moving original line defining step of defining one of the edge lines of the existing article shape as a first moving original line and defining another one of the edge lines other than the first moving original line as a second moving original line;

a normal plane cross sectional shape generating step of generating a cross sectional shape of the existing article formed by a normal plane at each node on the first moving original line;

a moving destination line designating step of designating a first moving destination line which is a destination of the first moving original line and a second moving destination line which is a destination of the second moving original line;

a similarity-like transformation cross sectional shape generating and rearranging step of rearranging a normal plane cross sectional shape which crosses the second moving original line by performing similarity-like transformation for moving a node belonging to the first moving original line to a corresponding point on the first moving destination line and moving a node on the second moving original line to a corresponding point on the second moving destination line; and

a cross sectional shape rearranging step of rearranging a normal plane cross sectional shape which does not cross the second moving original line to a corresponding point on the first moving destination line,

wherein a new article shape defined by a series of the similarity-like transformation cross sectional shapes and the normal plane cross sectional shapes which have been rearranged is generated.

51. A method according to claim 50, comprising:

a shape node providing step of providing shape nodes at predetermined intervals on the normal shape cross sectional shape, wherein

a shape node moves in accordance with a first shape node moving vector which is obtained by multiplying a first moving vector from a node belonging to the first moving original line

to the corresponding point on the first moving destination line by a ratio of a distance from the second moving original line to the shape node divided by a distance from the node on the first moving original line to a corresponding point on the second moving original line, and a shape node further moves in accordance with a second shape node moving vector which is obtained by multiplying a second moving vector from a node belonging to the second moving original line to the corresponding point on the second moving destination line by a ratio of a distance from the first moving original line to the shape node divided by a distance from the node on the second moving original line to a corresponding point on the first moving original line, thereby performing similarity-like transformation of the normal plane cross sectional shape.